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APPLICATION NUMBER: ***60/529,613***
FILING DATE: ***December 16, 2003***

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Certifying Officer

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No.

INVENTOR(S)		
Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Bill	Seabrook	Vaughan, Ontario, CANADA

Additional inventors are being named on the _____ *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

RADIAL LIGHT MOUNTING BLOCK

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☐ Customer Number:

OR

☑ Firm or Individual Name	Ridout & Maybee LLP				
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Country	CANADA	Telephone	416-868-1482	Fax	416-362-0823

ENCLOSED APPLICATION PARTS *(check all that apply)*

☑ Specification *Number of Pages* 11 ☐ CD(s), Number _____

☑ Drawing(s) *Number of Sheets* 8 ☐ Other (specify) _____

☐ Application Date Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☑ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees.

☐ The Director is herby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 13-2400

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE Amount ($): $80.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☑ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____

Respectfully submitted,

SIGNATURE _____

TYPED or PRINTED NAME David J. Heller

TELEPHONE 416-868-1482

Date December 15, 2003

REGISTRATION NO. 43,384 *(if appropriate)*

Docket Number: 43780-0001

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

RIDOUT & MAYBEE LLP
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Technology Law | Intellectual Property Law

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December 15, 2003

BY COURIER

U.S. Patent and Trademark Office
2011 South Clark Place
Customer Window, Mail Stop Provisional Patent Application
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U.S.A.

Dear Sirs:

Re: New U.S. Provisional Patent Application
Applicant: Bill Seabrook
Title: RADIAL LIGHT MOUNTING BLOCK
Our File: 43780-0001

Enclosed herewith is a provisional patent application for filing in the names of

We enclose the following documents:

Provisional Application for Patent Cover Sheet
Specification – 11 Pages
Abstract – 1 Page
Drawings – 8 Pages (Figures 1-11)
Fee - $80.00 (by deposit account)

Please deduct the requisite fee in the amount of $80.00 from our Deposit Account No. 13-2400. If any further fee is due, please also deduct it from our Deposit Account.

Yours very truly,

Bill Seabrook

By: _____
David J. Heller, Reg. No. 43,384

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file copy

TITLE: **LIGHTING ASSEMBLY**

FIELD OF THE INVENTION

[0001] The present invention relates to lighting assemblies, and more particularly to lighting assemblies for light emitting diode (LED) arrays.

BACKGROUND OF THE INVENTION

[0002] Light emitting diodes (LEDs) are generally more energy efficient, more reliable and have longer lifetimes than other types of lighting. One performance measure of an LED is its photometric efficiency, e.g. the conversion of input energy into visible light. Photometric efficiency is inversely proportional to the junction temperature of an LED. Junction temperature also affects the operational lifetime of LEDs. Accordingly, keeping the LED junction temperature cool is an important consideration in the design of LED devices.

[0003] Traditionally, heat dissipation of LEDs was provided by the lead wires of the LED itself. However, this technique is inefficient and limits the efficiency of LED devices. Another method for controlling LED junction temperature uses a heat sink slug to draw heat away from the LED. An example of such an apparatus is described in U.S. Patent No. 6,274,924 to Carey et al., issued August 14, 2001. An LED die is attached to the heat sink slug using a thermally conductive material or submount. The heat sink slug is inserted into an insert-molded leadframe. The heat sink slug may include a reflector cup. Bond wires extend from the LED to metal leads on the leadframe. The metal leads are electrically and thermally isolated from the slug. An optical lens may be used to focus the light emitted from the LED. This apparatus is useful for dissipating heat from the LED, however it requires that the heat be dissipated to air. This problem becomes exacerbated with high wattage LEDs and multiple LED devices where heat generation is greater. A solution to the external heat dissipation is not provided by the apparatus of Carey et al.

[0004] Control and focus of the light emitted from an LED is typically provided using a collimator such as those described in U.S. Patent No. 6,547,423 to Marshall et al., issued April 15, 2003. A collimator uses a lens and refractive walls to focus the light emitted from an LED. An LED and collimator combination yields a high level of efficiency in terms of control of emitted light or luminous flux.

[0005] The aiming of individual light sources so that the object or area of interest is properly lit is an important consideration. A known method of aiming individual light sources is an arrangement commonly referred to as a gimble ring. Gimble rings are known in the art and are commonly used in track lighting. Gimble rings work well with incandescent lights and other light sources that do not depend on a thermal circuit at the back of the lighting assembly. However, gimble rings are not suitable for light sources that require a thermal circuit at the back because the ring arrangement lacks the required surface area. Further, gimble ring-type arrangements are not appropriate for use in small spaces, for example, where clearance around the light source is limited or where several light sources are to be used close together.

[0006] Thus, there remains a need for a lighting assembly for an LED that provides adequate heat dissipation for single LED applications, high wattage LEDs and multiple LED devices. There is also a need for a lighting assembly for LEDs and other light sources requiring a thermal circuit at the rear which provides for the aiming of individual light sources.

SUMMARY OF THE INVENTION

[0007] The present invention is a heat sink and lighting assembly that can be used for mounting LEDs including higher wattage LEDs and multiple LED devices. Some embodiments of the present invention also provide a mechanism for the aiming of individual light sources that can be used in tight spaces and with light sources

requiring a thermal circuit at the rear. Some embodiments also provide for linear LED arrays to be used.

[0008] In accordance with one aspect of the present invention, there is provided a lighting assembly, comprising: a mounting having a concave mounting surface and defining an indexing channel; a seat having a front and rear surface, the seat including an indexer at the rear surface thereof, the indexer being received in the indexing channel; and a light source attached to the front surface of the seat.

[0009] In accordance with another aspect of the present invention, there is provided a lighting assembly, comprising: a thermally conductive mounting having a mounting surface; and a heat sink seat having a front and rear surface, the heat sink seat being moveably mounted to the mounting surface, wherein the shape of the mounting surface corresponds to the shape of the rear surface of the heat sink sea, wherein the front surface of the heat sink seat is configured to receive a light emitting device.

[0010] In accordance with a further aspect of the present invention, there is provided a heat sink, comprising: a thermally conductive mounting having a mounting surface; and a heat sink seat having a front and rear surface, the heat sink seat being moveably mounted to the mounting surface.

[0011] Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Reference will now be made to the accompanying drawings which show, by way of example, embodiments of the present invention, and in which:

[0013] FIG. 1 is a perspective view of one embodiment of a lighting assembly constructed according to the present invention;

[0014] FIG. 2 is an exploded perspective view of an LED module of the lighting assembly of FIG. 1;

[0015] FIG. 3 is a side view of the lighting assembly of FIG. 1;

[0016] FIG. 4 is a perspective view of the lighting assembly of FIG. 1 showing a flat and a wedge shaped LED module in isolation;

[0017] FIG. 5 is a perspective view of a housing containing the lighting assembly of FIG. 1;

[0018] FIG. 6 is a side view of the housing of FIG. 5;

[0019] FIG. 7 is a front view of the housing of FIG. 5;

[0020] FIG. 8 is a top view of the housing of FIG. 5;

[0021] FIG. 9 is a side view of an LED subunit for the lighting assembly of FIG. 1;

[0022] FIG. 10 is a side view of a second embodiment of a mounting for a lighting assembly constructed according to the present invention; and

[0023] FIG. 11 is a side view of a third embodiment of a mounting for a lighting assembly constructed according to the present invention.

[0024] Similar references are used in different figures to denote similar components.

DETAILED DESCRIPTION

[0025] Referring to FIG. 1 to 3, a lighting assembly 10 constructed according to present invention will be described. The lighting assembly 10 comprises a thermally conductive mounting 12 having a mounting surface 13 and a plurality of

light emitting diode (LED) modules 11 mounted along its major axis (X). Each LED module 11 comprises a heat sink seat 14 including a front surface 33 and rear surface 34, LED subunit 16 including an LED 18, and collimator 20. The thermally conductive mounting 12 is elongate and defines indexing channels or slots 22 for mounting the LED modules 11.

[0026] The mounting 12 may be constructed of aluminum or other suitable thermally conductive material such as copper or steel. The length of the mounting 12 may be varied to accommodate as many LED modules 11 as are desired for a particular lighting application. Typically, the indexing channels 22 are spaced such that the LED modules 11 are close together in groups or arrays. In other embodiments, the indexing channels 22 are spaced apart to provide a desired distance between the LED modules 11. In another embodiment, only one LED module 11 and indexing channel 22 are provided. In the present embodiment, the mounting surface 13 is a concave surface with the mounting 12 forming a trough. The rear surface 34 is a convex surface. The radius of the mounting surface 13 corresponds with the radius of the convex surface of the heat sink seat 14 to provide a thermal circuit of sufficient surface area to adequately dissipate the heat generated from the operation of the LEDs 18. The radius of the mounting surface 13 should be equal to or greater than the length of an LED module 11. Different shapes for the rear surface 34 and the mounting surface 13 may be used provided the surfaces match and form a contact area sufficient for an effective thermal circuit when the LED modules 11 are mounted. Typically, a thermally conductive surface wetting component such as thermal grease or a thermally conductive fixative such as thermal epoxy or thermal tape is used to improve surface contact between the rear surface 34 and the mounting surface 13. If movement of the LED modules 11 is to be provided in the assembled fixture a surface wetting component should be used. If movement of the LED modules 11 is not desired, a thermally conductive fixative may be used.

[0027] The heat sink seats 14 may be constructed of aluminum or other suitable thermally conductive material such as copper or steel. The front surface 33 of the heat sink seats 14 may be flat 30 or angled 31 (FIG. 4) forming what is referred

to as either a flat heat sink seat or an angle heat sink seat respectively. When mounted, the flat front surface 30 is substantially parallel to the major axis (X) of the mounting 12. In contrast, the angled front surface 31 is positioned at an angle to the major axis (X) of the mounting 12 when the heat sink seat 14 is mounted. Other shapes for the heat sink seats 14 are also possible. The heat sink seats 14 may be machined, cut, extruded, or otherwise formed. In one embodiment, the heat sink seats 14 are formed of extruded aluminum and have a flat front surface 30. If an angled front surface 31 is desired for some or all of the heat sink seats 14, the angled front surface 31 is subsequently machined from an extruded flat heat sink seat.

[0028] Referring now to FIG. 9, an LED subunit 16 will be described in more detail. The LED subunit 16 comprises the LED 18, lens 50, a heat sink slug 52, and a thermally conductive substrate 54. Thermal epoxy or similar fixative is used to attach the LED 18 to the heat sink slug 52 and the heat sink slug 52 to the substrate 54. The heat sink slug 52 is constructed of a thermally conductive material such as aluminum and may include an optical reflector cup 53 which may be attached to or integrally formed with the heat sink slug 50. The reflector cup 53 may be made of thermally conductive materials such as aluminum that have been plated for reflectivity. The substrate 54 provides a large surface area for heat transfer in a thermal circuit. In some embodiments, the substrate 54 is part of a metal-core printed circuit board. In such cases, the circuit board includes electrical connections for the LED 18. In some embodiments, the LED subunits 16 are Luxeon™ LED light sources such as a Luxeon™ Star LED from Lumileds Lighting, LLC (San Jose, California, USA). Insulation 55 may be provided to shield the LED 18 and the heat sink slug 52.

[0029] Each heat sink seat 14 includes an indexer 24 (FIG. 3) on its rear surface 34. The indexer 24 may be attached to or formed integrally with the heat sink seat 14. The indexer 24 of each heat sink seat 14 is received in a corresponding indexing channel 22 in the mounting 12. The indexer 24 is used to position and secure the corresponding LED module 11 to the mounting 12. The indexer 24 may be a threaded member adapted for receiving a nut. In some embodiments, the indexer 24 is a screw which is threaded into the rear surface 34 of the heat sink seat

14. Other methods of fixing the indexer 24 in the corresponding indexing channel 22 may also be used, for example, friction fits and cammed levers. Using the indexer 24, an LED module 11 can be slid through a range of mounting positions provided by the indexing channels 22 until the desired mounting position for the LED module 11 is obtained. The indexing path (Z) is limited by the upper and lower ends of the indexing channels 22 which define upper and lower limit positions for the LED modules 11 respectively. In this manner, indexing of the LED modules 11 allows the lighting assembly 10 to be customized to the lighting environment and conditions of a particular lighting task. Using the indexing mechanism, LED modules 11 may be individually aimed as required to accomplish the lighting task. Various forms of indicia may be used to mark mounting positions or angles for the indexing channels 22 for ease of assembly. The indexing mechanism can also be used with non-LED light sources to aim or target individual light sources.

[0030] In other embodiments, the LED modules 11 are mounted using a suitable thermally conductive adhesive rather than using indexers and channels. In such cases, the LED modules 11 are mounted directly to the mounting 12 to create an effective thermal circuit. Different shapes for the mounting 12 may be used, and the indexing mechanism described above may be substituted for an alternative mechanical fastening means so long as such modifications provide an effective thermal circuit for dissipating heat generated by the LEDs 18.

[0031] Many different types of LEDs are known in the art. In some embodiments, the LED 18 is formed of a light-emitting diode die. Power consumption and colour of the light emitted are two considerations affecting the selection of an appropriate LED for a particular lighting application. In some embodiments, a 1 to 5 W LED is used. In other embodiments, a 1 to 3 W LED is used. In yet other embodiments, a 3 W LED is used.

[0032] Typically, the light emitted from the LED 18 is focused to narrow its beam width. A collimator 20 having a lens 21 is attached to the heat sink slug to focus the light emitted therefrom. The collimator 20 is attached so that the lens 21 is close to and positioned over the LED 18. For some utility lighting applications, the

light beam emitted from the LED 18 is focused to create a beam width of approximately 9 degrees. Examples of a collimator that can be used with the present invention are described in U.S. Patent No. 6,547,423, issued April 15, 2003. Many different types of collimators are known in the art. The collimator selected affects the properties of the light beam that is obtained. The LED 18 and collimator 20 should be properly selected to obtain the desired lighting characteristics for a particular lighting task.

[0033] Referring now to FIG. 5 to 8, a housing 40 for the lighting assembly 10 will be described. The housing 40 defines a plurality of apertures 41 which may be protected by a transparent cover (not shown). The housing 40 is made of a thermally conductive material such as steel or aluminum. A mounting portion 25 of the mounting 12 defines a number of holes which can be used to secure the lighting assembly 10 within the housing 40 using screws or other suitable fasteners. The mounting portion 25 thermally connects the mounting 12 and the housing 40 allowing the housing 40 to dissipate heat from the mounting 12 by conduction. Convection with outside air draws heat away from the housing 40.

[0034] Typically, the LED modules 11 are aimed through the apertures 41 at an area or object to be illuminated. Using the indexing mechanism described above, LED modules 11 may be individually aimed to direct the light emitted therefrom through a narrow aperture 41 or lens reducing the overall required size of a lighting fixture. Additional aiming of the LED modules 11 may be provided by using an angled heat sink seat rather than a flat heat sink seat. The housing 40 and protective cover (not shown) may be used to protect the lighting assembly 10 from rain, snow, dust, and other environmental elements when used for exterior lighting applications. The housing 40 and protective cover also protect against unwanted access, for example, for the safety of bystanders and to minimize or prevent tampering with the lighting assembly 10.

[0035] Referring now to FIG. 10, a second embodiment of a mounting 60 for a lighting assembly will be described. The mounting 60 includes a mounting surface 62 similar to the mounting surface 13. The mounting 60 is similar to the mounting 12

in several respects, however the mounting 60 includes a plurality of longitudinally xtending fins 64 on its rearward side. The fins 64 may be attached to the housing 40 to secure the mounting 60 using screws, rivets, or other suitable fasteners. The fins 64 increase the surface area of contact between the mounting 60 and the housing 40, increasing heat transfer and providing a more effective thermal circuit, . The mounting 60 is preferable for higher power applications such as high wattage LEDs and/or multiple LED devices.

[0036] Referring to FIG. 11, a third embodiment of a mounting 70 for a lighting assembly will be described. The mounting 70 comprises a plurality of facetted members or facets 72. The facets 72 are thin, longitudinally extending members formed of a thermally conductive material such as aluminum or carbon steel. The facets 72 may be separate members attached in series using a thermally conductive adhesive or other suitable fastening means, or the facets 72 may be formed integral with one another, for example by using a hydraulic brake to shape a piece of base material. The facets 72 meet at a desired mating angle (B°). The mating angle between the facets 72 is selected to provide the desired range of indexing positions for mounting the LED modules 11. In one embodiment, a mating angle of 15° is used. As in previous embodiments, the rear surface 34 of the heat sink seats 14 must correspond in shape to the shape of the facets 72.

[0037] Generally, light emitted from the lighting assembly 10 is directed laterally towards an object or area to be illuminated. Depending on the aiming of the LED modules 11, the light beam may also be directed laterally and downwardly, or laterally and upwardly towards the object or area to be illuminated.

[0038] The lighting assembly of the present invention has many applications, including low mounted utility lighting. The lighting assembly 10 may be installed at levels much lower than that of typical light standards, for example, below a handrail for lighting an adjacent walkway or street. Other applications include the installation of the lighting assembly 10 in a ceiling recess to illuminate an area or object while hiding the fixture from plain view. The coupling of the LED 18 to a heat sink seat 14 and thermally conductive mounting 12 creates a thermal circuit for the LEDs 18 which

maintains an LED junction temperature that is lower than is otherwise possible, improving reliability and performance of the LEDs 18 because the LEDs 18 are not subject to high thermal stress. Much of the heat generated by the LED 18 is ultimately transferred to the housing 40 where convection with outside air dissipates the heat.

[0039] Advantages of the lighting assembly of the present invention include the assembly is linear, modular, easy to manufacture, can be used in tight spaces, and provides flexibility in design. The lighting assembly provides a linear array of LEDs which are modular and can be added or removed, and individually aimed as desired. The assembly is also modular in that two or more lighting assemblies may be used for a particular lighting task and arranged as desired. The lighting assembly also provides many targetable (directional) lights which can be used in tight spaces where clearance around the light is limited.

[0040] Several variations of the lighting assembly of the present invention are possible. Minimal heat dissipation occurs from the mounting 12 by convection. If desired, appropriate openings may be defined in the housing 40 to allow air flow through the housing 40. In such cases, air flow may be increased using a fan to increase convection and heat dissipation from the mounting 12. In some embodiments other lights such as incandescent lights may be used with the invention. In some embodiments, two or more LED modules may be mounted within the same indexing channel. In other embodiments, the heat sink seats also include cooling fins. The cooling fins may be attached to or formed integrally with the heat sink seats. In yet other embodiments, two or more LEDs (same or different) may be coupled to one heat sink seat. In such cases, a collimator is used for each LED. The collimators for each may be separate components or formed integrally with one another. Although the use of the lighting assembly has been described with reference to a horizontal orientation, it is also possible for the lighting assembly to be used vertically.

[0041] Although the present invention has been described with reference to illustrative embodiments, it is to be understood that the invention is not limited to

these precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art. All such changes and modifications are intended to be encompassed in the appended claims.

WHAT IS CLAIMED IS:

1. A lighting assembly, comprising:

a mounting having a concave mounting surface and defining an indexing channel;

a seat having a front and rear surface, said seat including an indexer at the rear surface thereof, said indexer being received in said indexing channel; and

a light source attached to the front surface of said seat.

2. A lighting assembly, comprising:

a thermally conductive mounting having a mounting surface; and

a heat sink seat having a front and rear surface, said heat sink seat being moveably mounted to said mounting surface, wherein the shape of said mounting surface corresponds to the shape of the rear surface of said heat sink sea, wherein the front surface of said heat sink seat is configured to receive a light emitting device.

3. The lighting assembly as claimed in claim 2, wherein said light emitting device is a light emitting diode (LED) thermally coupled to the front surface of said heat sink seat.

4. The lighting assembly as claimed in claim 2, wherein said light emitting device is a Luxeon Star LED.

5. The lighting assembly as claimed in claim 3, wherein the rear surface of said heat sink seat forms a convex surface and said mounting surface forms a concave surface, and wherein the radius of said convex surface corresponds to the radius of said concave surface.

6. The lighting assembly as claimed in claim 5, wherein said mounting and said heat sink seat are formed of aluminum.

7. The lighting assembly as claimed in claim 2, wherein said heat sink seat includes a front portion forming a wedge for angling said light emitting device.

8. The lighting assembly as claimed in claim 5, wherein said mounting defines an indexing channel for mounting said heat sink seat, and wherein said heat sink seat further includes an indexer at the rear surface thereof, said indexer being received in said indexing channel.

9. The lighting assembly as claimed in claim 8, wherein said mounting defines a plurality of indexing channels corresponding to a plurality of said heat sink seats.

10. The lighting assembly as claimed in claim 8, further comprising a collimator including a lens attached to the front surface of said heat sink seat, wherein said lens is operably positioned over said LED for focusing the light emitted therefrom.

11. The lighting assembly as claimed in claim 5, further comprising:

a plurality of LEDs thermally coupled to the front surface of said heat sink seat;

a plurality of collimators including a lens attached to the front surface of said heat sink seat, wherein each said lens is operably positioned over one LED in the plurality of LEDs for focusing the light emitted therefrom.

12. The lighting assembly as claimed in claim 10, further comprising a heat sink slug thermally connected to said LED and thermally coupled to the front surface of said heat sink seat.

13. The lighting assembly as claimed in claim 12, further comprising a thermally conductive substrate having a top and bottom surface, wherein the top surface of said substrate is thermally connected to said heat sink slug, and wherein the bottom surface of said substrate is thermally connected to the front surface of said heat sink seat.

14. The lighting assembly as claimed in claim 13, wherein the surface area of the bottom surface is sufficient to create an effective thermal circuit.

15. The lighting assembly as claimed in claim 10, wherein the radius of said concave surface is equal to or greater than the distance from the rear surface of said heat sink seat to a top surface of the collimator.

16. The lighting assembly as claimed in claim 8, wherein said mounting is a longitudinally extending thermally conductive mounting having a mounting surface and a major axis, and wherein said heat sink seat is moveably mounted along the major axis of said mounting.

17. The lighting assembly as claimed in claim 8, wherein said indexing channels are transverse indexing channels.

18. The lighting assembly as claimed in claim 8, wherein said indexing channel includes an upper and lower limit position defined by the respective ends of said indexing channel, wherein said heat sink seat is moveable between said upper and lower limit positions.

19. The lighting assembly as claimed in claim 8, further comprising a longitudinally extending thermally conductive housing defining an aperture on a first wall thereof, and wherein said mounting includes a mounting portion, and wherein said mounting portion is thermally connected to said housing, and wherein said LED may be aimed through said aperture at an area or object to be illuminated.

20. The lighting assembly as claimed in claim 8, wherein said mounting further includes a rearward side and a plurality of longitudinally extending fins extending from the rearward side of said mounting.

21. A heat sink, comprising:

a thermally conductive mounting having a mounting surface; and

a heat sink seat having a front and r ar surface, said heat sink seat being moveably mounted to said mounting surface.

22. The heat sink as claimed in claim 21, wherein the shape of said mounting surface corresponds to the shape of the rear surface of said heat sink seat.

ABSTRACT

A lighting assembly includes a thermally conductive mounting having a mounting surface. A heat sink seat having a front and rear surface is moveably mounted to the mounting surface. A light emitting device can be attached to the front surface of the heat sink seat.

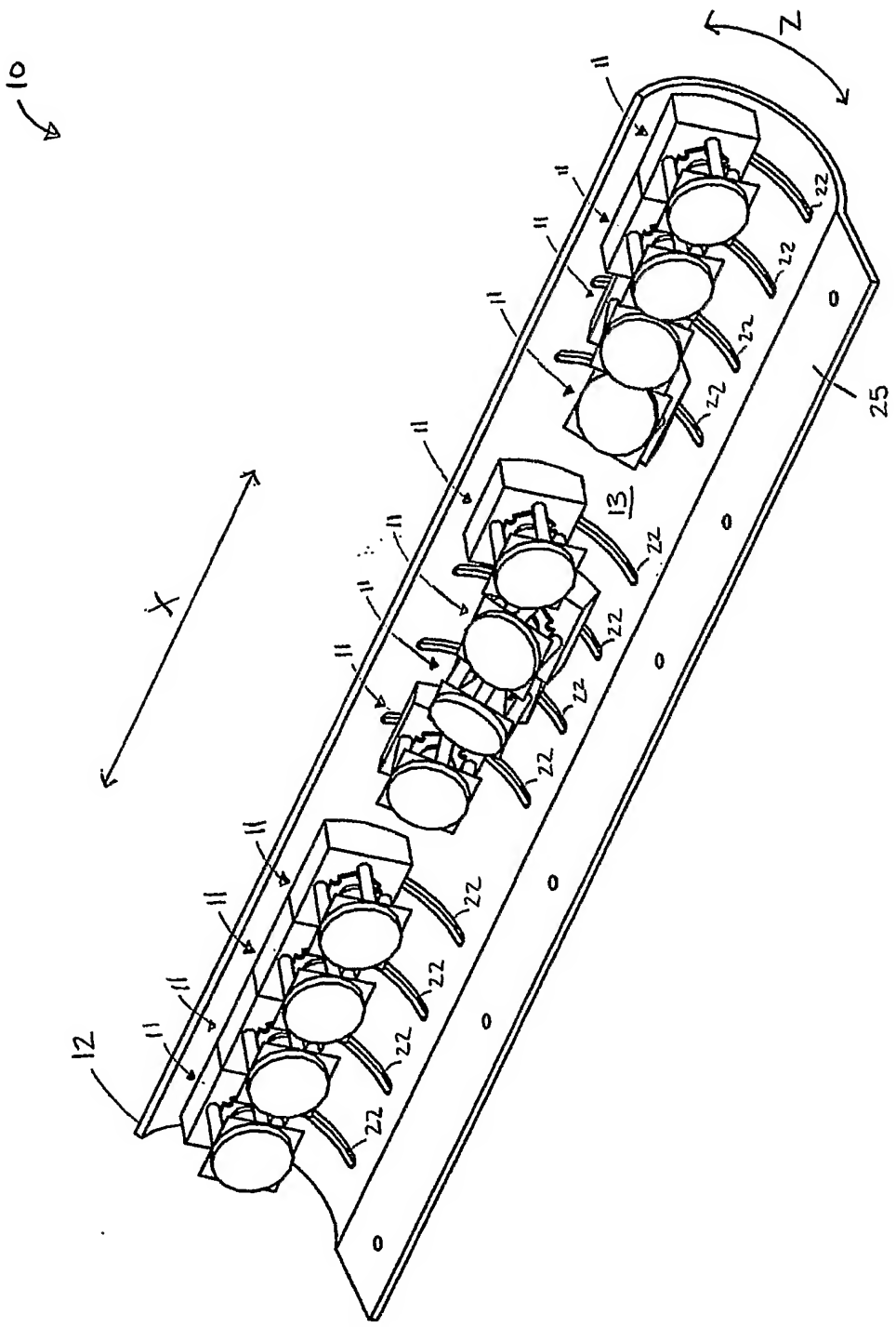

FIG. 1

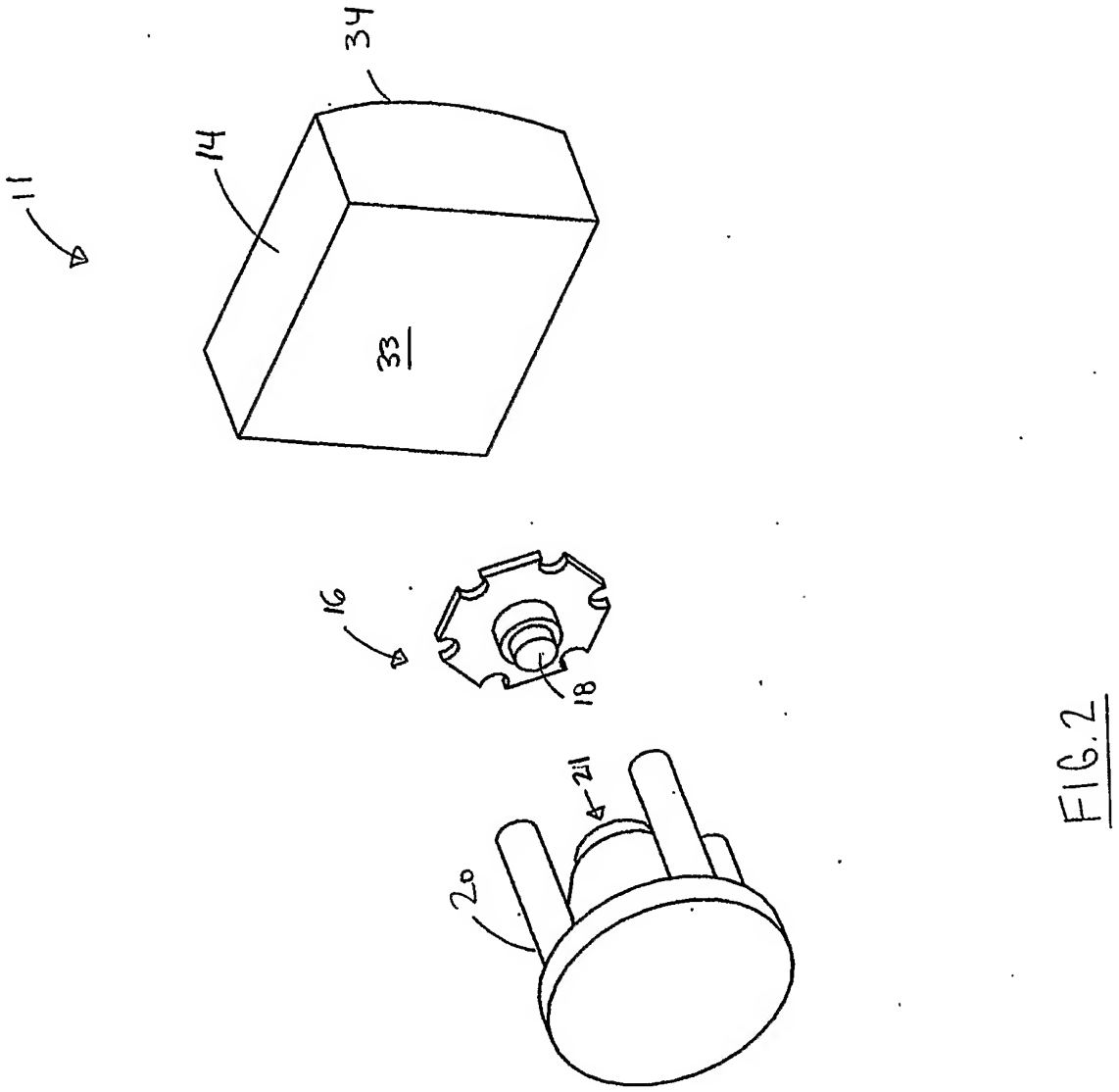

FIG. 2

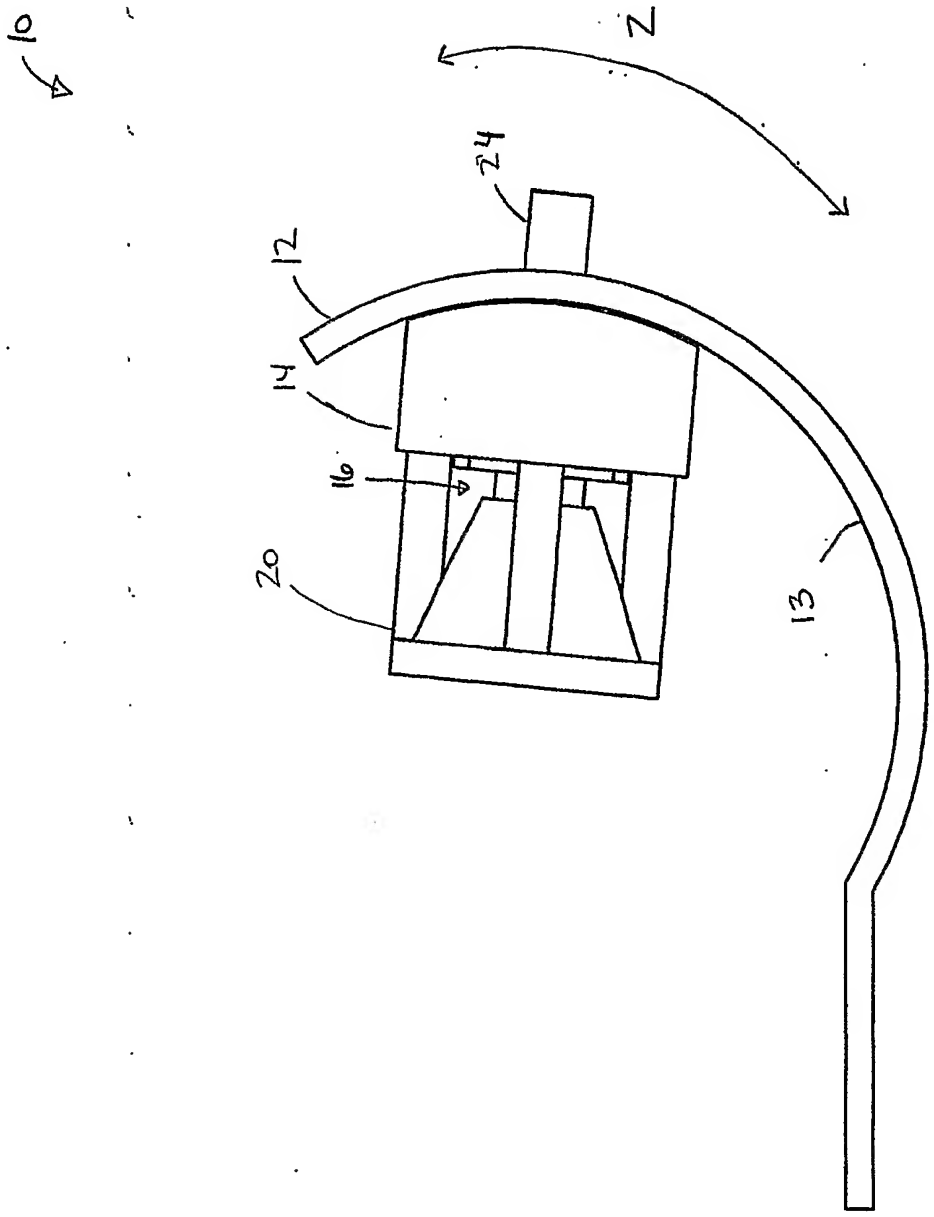

FIG. 3

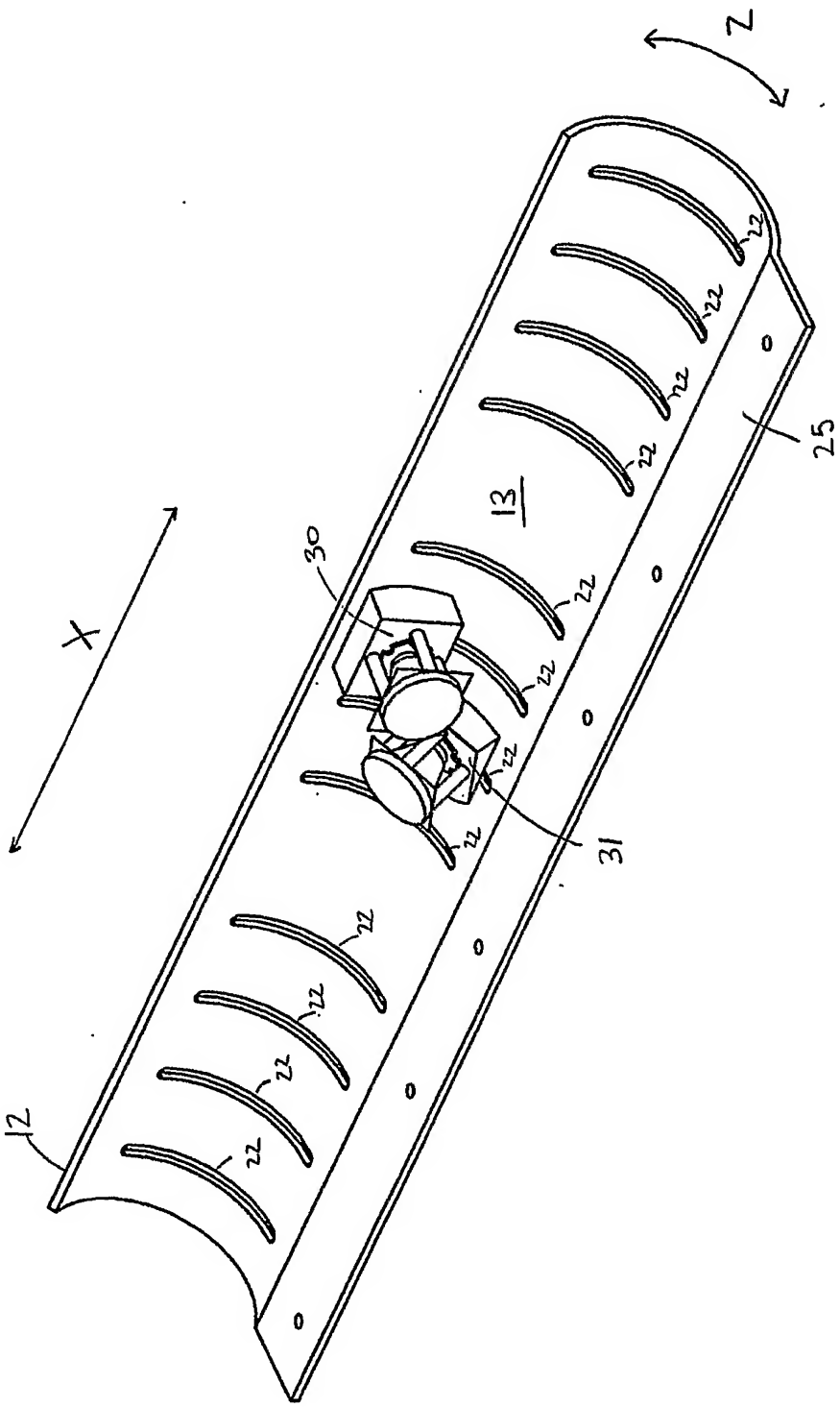

FIG. 4

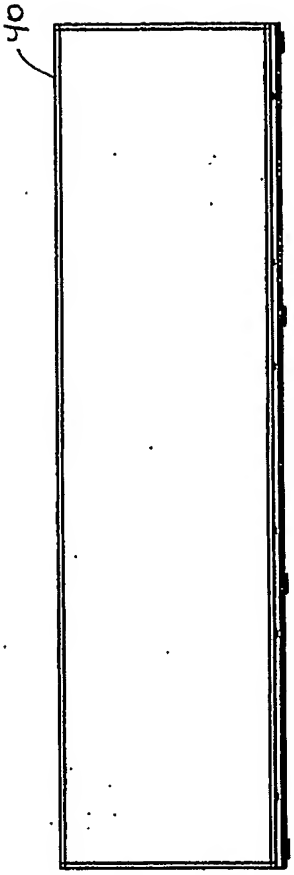

FIG. 8

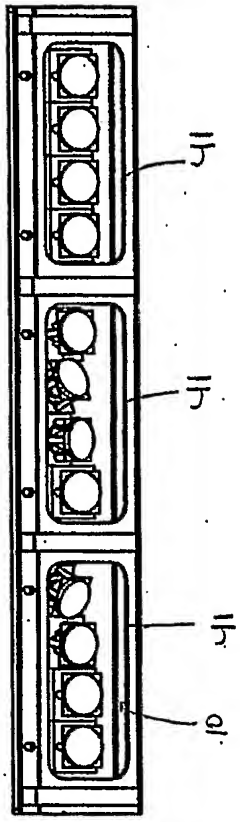

FIG. 7

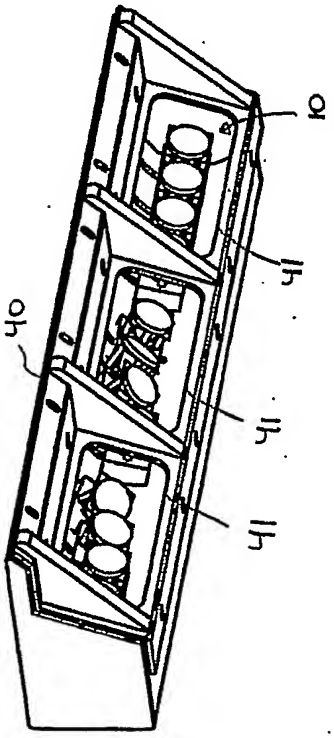

FIG. 5

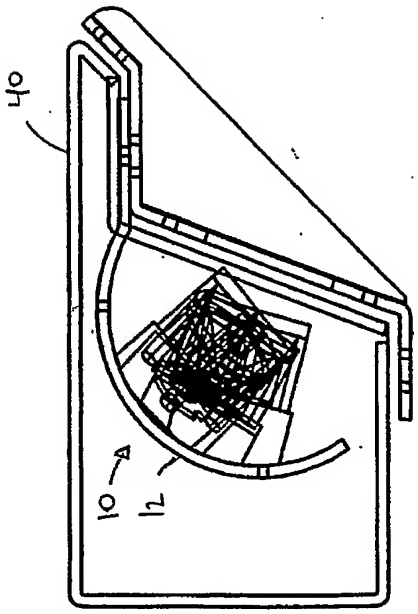

FIG. 6

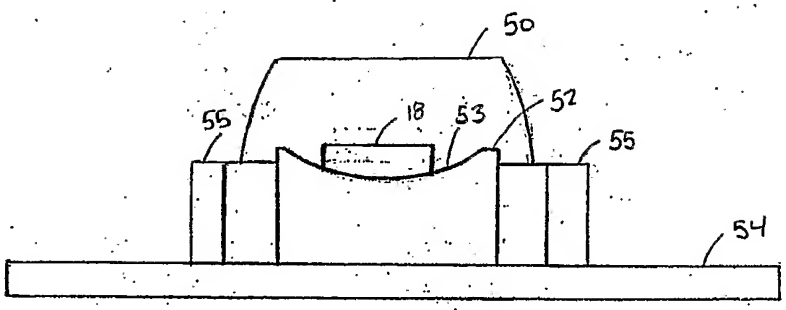

FIG. 9

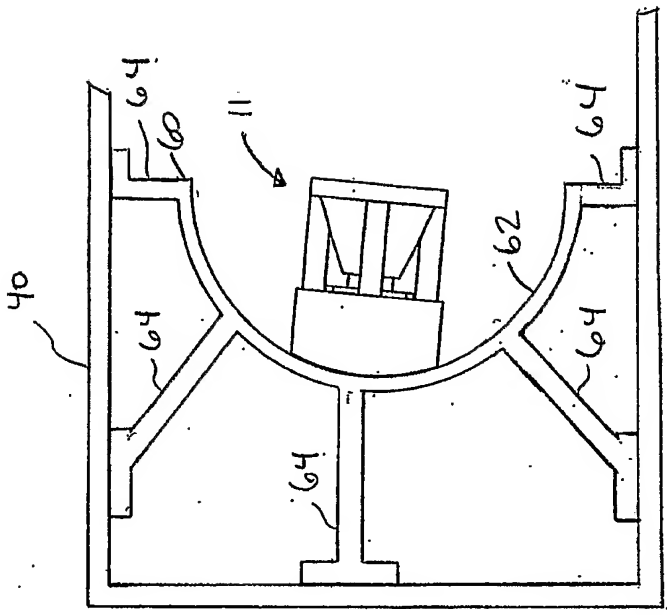

FIG. 10

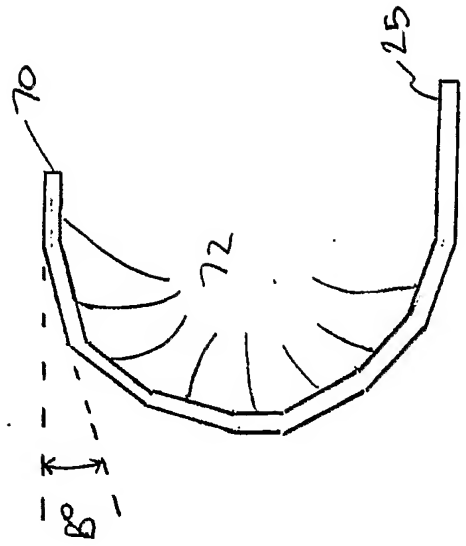

FIG. 11